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A VLBI polarization study of SiO masers towards VY CMa

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Abstract. Maser emission from the SiO molecule has been widely observed in the near-circumstellar envelopes of late-type, evolved stars. VLBI images can resolve individual SiO maser spots, providing information about the kinematics and magnetic field in the extended atmospheres of these stars. This poster presents full polarization images of several SiO maser lines towards the supergiant star VY CMa. VY CMa is a particularly strong SiO maser source and allows observations of a wide range of maser transitions. We discuss implications of these observations for VY CMa morphology, polarization, and pumping models.

Keywords. stars: late-type, polarization

1. Introduction

SiO maser emission has been widely observed in the near-circumstellar envelopes of late-type evolved stars. VLBI images can resolve individual SiO maser spots around these stars, providing information about the kinematics and magnetic field close to the stellar surface at high spatial resolution. Comparison of the emission from different SiO maser lines may provide insight into the pumping mechanisms providing the population inversion necessary for the masers and also holds promise in discriminating between competing SiO maser polarization models.

2. Observations

The source VY CMa was observed with the Very Long Baseline Array (VLBA) on 2 December 1994 (epoch 1) and 20 and 23 December 2003 (epoch 2). The data were reduced and imaged with AIPS following the technique described by Kemball & Diamond (1995). Several SiO maser lines were observed, three of which are shown in Figure 1. Unfortunately there was very little data for each of the epoch 2 lines and the signal to noise ratio is lower than it is in epoch 1.

3. Discussion

The intensity of the imaged maser emission in epoch 1 was significantly higher than the intensity of any of the epoch 2 lines. The epoch 2 v=1 J=1-0 and v=2 J=1-0 emission has a very similar spatial distribution. These maps in Figure 1 were aligned by correlating the images, channel by channel. There is no obvious trend in the direction of the polarization vectors between epochs.

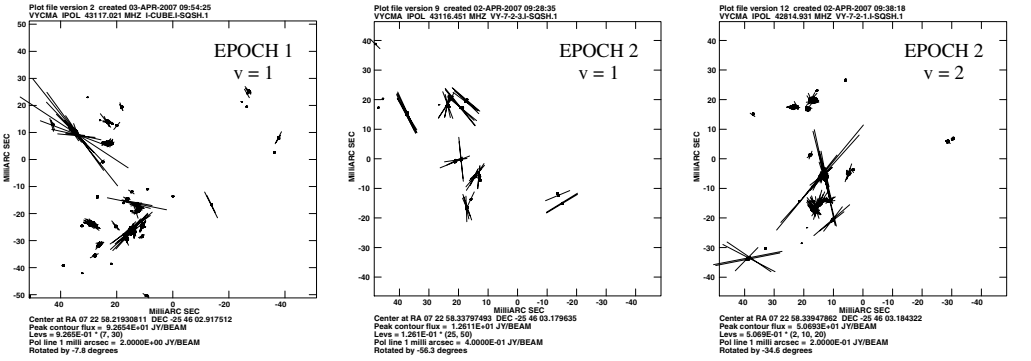

Figure 1. 43 GHz J=1-0 SiO masers towards VY CMa. The intensity is given by the contours and the magnitude and direction of the linear polarisation are represented the vectors.

3.1. *Pumping models*

The primary pumping mechanism driving SiO maser emission remains an issue of dispute in the literature. Models of masers in the circumstellar environment make use of both radiative pumping (e.g. Bujarrabal 1994) and collisional pumping (e.g. Lockett & Elitzur 1992; Doel *et al.* 1995).

One means to identify the primary pumping mechanism at work is to compare the spatial distribution of different vibrationally-excited SiO maser lines. The spatial coincidence of the rotational transitions in different vibrational lines, such as the v=1 and v=2 J=1-0 lines, would argue against a radiative pumping model (Bujarrabal 1994; Doel *et al.* 1995). Kinematic models of the SiO maser emission, using collisional pumping, predict that the v=1 J=1-0 emission should lie further from the star than the v=2 J=1-0 emission, in a thicker shell (Gray & Humphreys 2000).

In the epoch 2 maps above, the v=1 J=1-0 and v=2 J=1-0 maps have many overlapping features and a similar overall distribution. The overlap of several features in the aligned v=2 J=1-0 and v=1 J=1-0 maps argues against purely radiative pumping. Where the v=1 and v=2 features overlap, the v=2 features generally extend inwards further than the v=1 features.

We cannot draw definitive conclusions from comparisons of different rotational lines at just one epoch. Further observations in this area are continuing.

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